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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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EXAMINER	
KENNEDY, JENNIFER M	

ART UNIT	PAPER NUMBER
2812	

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/982,953	Applicant(s) MCTEER, ALLEN	
	Examiner Jennifer M. Kennedy	Art Unit 2812	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 July 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *22-35,58 and 60-62* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *22-35, 58, 60-62* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on July 22, 2005 has been entered.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 22-35, 58, and 60-62 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chiang et al. (U.S. Patent No. 5,739,579) in view of Moslehi et al. (U.S. Patent No. 6,016,000).

In re claim 22, Chiang et al. disclose the method of forming a copper interconnect structure providing electrical connection for a semiconductor device (see column 5, lines 25-31, and column 12, line 64 through column 13, line 5), comprising the steps of;

forming a first contact opening into a first insulating layer (350) formed over a semiconductor substrate (320);

forming a conductive plug in the first contact opening (360, 361), wherein the conductive plug is in contact with said first insulating layer;

forming a second insulating layer (391) over the conductive plug and said first insulating layer;

forming a second contact opening in the second insulating layer (391);

forming a barrier layer (393) in the second contact opening;

forming a copper conductor (394) over the barrier layer; and

forming a top etch stop/heat radiating layer (392) wherein said heat-radiating layer is formed completely on an upper surface portion (see column 21, lines 4-16) of said copper conductor (394), said top heat-radiating layer passifying said upper surface portion of said copper conductor (see specifically column 15, lines 16-25, and column 20, lines 24-33, the method explained in detail with reference to the lower interconnect layer, the details given in column 12, line 53, through column 20, line 24).

Chiang et al. does not disclose the method of forming the etching stop/heat-radiating passivation layer of aluminum nitride. Moslehi discloses the method of forming an etch stop/heat radiating passivation layer of aluminum nitride (see column 13, lines 32-38, and lines 55-60).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the etch stop layer of aluminum nitride, since as Moslehi teaches AlN is an alternative choice to that of the silicon nitride etch stop layer formed in Chiang et al. Further, Moslehi teaches AlN has the advantage of high thermal conductivity (see column 12, lines 32-50, and column 14, lines 16-60). The examiner

notes that the combined Chiang et al. and Moslehi teach that the silicon nitride or aluminum nitride is used as an etch stop layer, the heat-radiating effect of silicon nitride and aluminum nitride is an intrinsic material property (see Moslehi column 12, lines 32-50, and column 14, lines 48-60), and thus the aluminum nitride layer of Moslehi as incorporated into Chiang et al. would have acted as both a etch stop layer and a heat radiating layer.

In re claim 23, Chiang et al. also disclose the method of chemical mechanical polishing (CMPing) the copper layer and the barrier layer (see column 20, lines 1-3).

In re claim 24, Chiang et al. does not disclose the method of cleaning the upper surface portion of the copper conductor prior to the formation of the aluminum nitride layer. Moslehi discloses the method of cleaning the upper surface portion of the copper conductor prior to the formation of the aluminum nitride layer (see column 12, lines 32-35). It would have been obvious to one of ordinary skill in the art at the time the invention was made to clean the upper surface portion of the copper conductor prior to the formation of the aluminum nitride layer in order to remove contaminants from the surface.

In re claim 25, the combined Chiang et al. and Moslehi disclose the method wherein the etch stop/heat radiating layer of aluminum nitride is formed to a thickness of approximately 300 angstroms (see Chiang et al. column 15, lines 15-25)

In re claim 26 and 27, Moslehi discloses the method of forming the aluminum nitride layer by sputtering deposition (see column 13, lines 15-17, and column 14, lines 45-46 for Moslehi definition of PVD).

In re claim 28, Chiang discloses the method wherein the barrier layer is formed of a refractory metal compound being selected from the group consisting of refractory metal nitrides, refractory metal carbides, and refractory metal borides (see column 19, lines 4-10).

In re claim 29, Chiang et al. disclose the method of forming an interconnect structure providing electrical connection for a semiconductor device (see column 5, lines 25-31, and column 12, line 64 through column 13, line 5), comprising the steps of;

forming a contact opening in an insulating layer (350) of said device;

forming a first conductive plug (361) within said contact opening; and

forming a etch stop/heat radiating layer (390) wherein said heat-radiating layer is formed completely on an upper surface portion (see column 20, lines 33-47) of said first conductive plug; and

depositing a second conductive plug (393, 394) on said heat-radiating layer in contact with said first conductive plug (see specifically column 15, lines 16-25, and column 20, lines 24-33, the method explained in detail with reference to the lower interconnect layer, the details given in column 12, line 53, through column 20, line 24).

Chiang et al. does not disclose the method of forming the etching stop/heat-radiating passivation layer of aluminum nitride. Moslehi discloses the method of forming an etch stop/heat radiating passivation layer of aluminum nitride (see column 13, lines 32-38, and lines 55-60).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the etch stop layer of aluminum nitride, since as Moslehi teaches AlN is an alternative choice to that of the silicon nitride etch stop layer formed in Chiang et al. Further, Moslehi teaches AlN has the advantage of high thermal conductivity (see column 12, lines 32-50, and column 14, lines 16-60). The examiner notes that the combined Chiang et al. and Moslehi teach that the silicon nitride or aluminum nitride is used as an etch stop layer, the heat-radiating effect of silicon nitride and aluminum nitride is an intrinsic material property (see Moslehi column 12, lines 32-50, and column 14, lines 48-60), and thus the aluminum nitride layer of Moslehi as incorporated into Chiang et al. would have acted as both a etch stop layer and a heat radiating layer.

In re claim 30, Chiang et al. also disclose the method of forming a barrier layer (360) in said contact opening and before said step of depositing said first conductive plug.

In re claim 31, Chiang et al. does not disclose the method of cleaning the upper surface portion of the copper conductor prior to the formation of the aluminum nitride layer. Moslehi discloses the method of cleaning the upper surface portion of the copper conductor prior to the formation of the aluminum nitride layer (see column 12, lines 32-35). It would have been obvious to one of ordinary skill in the art at the time the invention was made to clean the upper surface portion of the copper conductor prior to

the formation of the aluminum nitride layer in order to remove contaminants from the surface.

In re claim 32, the combined Chiang et al. and Moslehi disclose the method wherein the aluminum nitride is formed to a thickness of approximately 300 angstroms (see Chiang et al. column 15, lines 15-25)

In re claim 33 and 34, Moslehi discloses the method of forming the aluminum nitride layer by sputtering deposition (see column 13, lines 15-17, and column 14, lines 45-46 for Moslehi definition of PVD).

In re claim 35, Chiang discloses the method wherein said first conductive plug is selected form the group consisting of aluminum, gold, silver, tungsten and copper (see column 19, lines 4-20).

In re claim 58, Chiang et al. disclose the method of forming a copper interconnect structure providing electrical connection for a semiconductor device (see column 5, lines 25-31, and column 12, line 64 through column 13, line 5), comprising the steps of;

forming a first contact opening into a first insulating layer (322) formed over a semiconductor substrate (320);

forming a first conductive plug in the first contact opening (342);

forming a second insulating layer (350) over the conductive plug and said first insulating layer;

forming a second contact opening in the second insulating layer;

forming a barrier layer (360) in the second contact opening;

forming a second conductive plug (361) over the barrier layer; and

forming a etch stop/heat radiating layer (390) across an entire upper surface) wherein said heat-radiating layer is formed completely on an upper surface portion (see column 21, lines 4-16) of said second conductive plug (see specifically column 15, lines 16-25, and column 20, lines 24-33, the method explained in detail with reference to the lower interconnect layer, the details given in column 12, line 53, through column 20, line 24).

Chiang et al. does not disclose the method of forming the etching stop/heat-radiating passivation layer of aluminum nitride. Moslehi discloses the method of forming an etch stop/heat radiating passivation layer of aluminum nitride (see column 13, lines 32-38, and lines 55-60).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the etch stop layer of aluminum nitride, since as Moslehi teaches AlN is an alternative choice to that of the silicon nitride etch stop layer formed in Chiang et al. Further, Moslehi teaches AlN has the advantage of high thermal conductivity (see column 12, lines 32-50, and column 14, lines 16-60). The examiner notes that the combined Chiang et al. and Moslehi teach that the silicon nitride or aluminum nitride is used as an etch stop layer, the heat-radiating effect of silicon nitride and aluminum nitride is an intrinsic material property (see Moslehi column 12, lines 32-50, and column 14, lines 48-60), and thus the aluminum nitride layer of Moslehi as incorporated into Chiang et al. would have acted as both a etch stop layer and a heat radiating layer.

In re claims 60-62, the combined Chiang et al. and Moslehi disclose the method wherein the etch stop/heat radiating layer of aluminum nitride is formed from approximately 100 angstroms to approximately 1000 angstroms thick (see Chiang et al. column 15, lines 15-25).

Response to Arguments

Applicant's arguments filed July 22, 2005 have been fully considered but they are not persuasive.

The Applicant argues that Chiang et al. does not disclose the method of forming a tip heat-radiating layer formed completely on an upper surface portion of a copper conductor or first conductive plug. The examiner disagrees and notes that Chiang et al. discloses forming a top etch stop/heat radiating layer (392) wherein said heat-radiating layer is formed completely on an upper surface portion (see column 21, lines 4-16) of said copper conductor (394). Specifically, Chiang et al. teaches the etch stop layer of silicon nitride that acts as a heat-radiating layer is "formed over dielectric layer 391 and the via plug in the dielectric layer 391, including conductive layer 394 and barrier layer 393."

Similarly, with respect to the rejection of claim 29, Chiang et al. teaches forming a etch stop/heat radiating layer (390) wherein said heat-radiating layer is formed

completely on an upper surface portion (see column 20, lines 33-47) of said first conductive plug; and

The examiner notes that Applicant's present claims do not preclude etching of the etch stop/heat radiation layer after deposition.

The examiner notes that Chiang et al. is relied upon to show the method of forming the interconnect layers with etch stop/heat radiating silicon nitride layers and Moslehi is relied upon to show that silicon nitride and aluminum nitride are interchangeable in the art of interconnects as etch stop/heat radiating layers. The examiner notes that the motivation for combining has been clearly set forth in the rejections above and is as follows:

It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the etch stop layer of aluminum nitride, since as Moslehi teaches AlN is an alternative choice to that of the silicon nitride etch stop layer formed in Chiang et al. Further, Moslehi teaches AlN has the advantage of high thermal conductivity (see column 12, lines 32-50, and column 14, lines 16-60). The examiner notes that the combined Chiang et al. and Moslehi teach that the silicon nitride or aluminum nitride is used as an etch stop layer, the heat-radiating effect of silicon nitride and aluminum nitride is an intrinsic material property (see Moslehi column 12, lines 32-50, and column 14, lines 48-60), and thus the aluminum nitride layer of Moslehi as incorporated into Chiang et al. would have acted as both a etch stop layer and a heat radiating layer.

Applicant argues that Moslehi discloses using AlN as a passivation layer and not as an etch stop. The examiner disagrees and notes that Moslehi does disclose that AlN can be used as an etch stop (see column 12,lines 44-50).

Applicant also argues that the second conductive plug is not formed on heat-radiating layer. The examiner notes that the only claim that requires that the conductive plug to be on the heat-radiating layer is Claim 29. The examiner notes that layers 393 and 394 are relied upon to show the second conductive plug formed on the heat radiating layer (390) and in electrical contact with the first conductive plug.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Tehrani et al. (U.S. Patent No. 5,861,328), Rosenblum et al. (U.S. Patent No. 5,567,523) and Kim et al. (U.S. Patent No. 5,270,263) disclose the use of AlN as an etch stop layer.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Jennifer M. Kennedy whose telephone number is (571) 272-1672. The examiner can normally be reached on Mon.-Fri. 9:30-6:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael S. Lebentritt can be reached on (571) 272-1873. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Jennifer M. Kennedy
Jennifer M. Kennedy
Primary Examiner
Art Unit 2812

jmk